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INDEX TO BENET LABORATORIES TECHNICAL REPORTS - 2000

R. D. NEIFELD

MAY 2001



US ARMY ARMAMENT RESEARCH, DEVELOPMENT AND ENGINEERING CENTER

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The U.S. Army and Air Force's standard also designates erosion condemnation or charge/projectile combination. These or factor for each charge/projectile combination cocurs much quicker than fatigue conde experimental method using the Unified M829A2 kinetic energy round types use obvious extension of this method to any factors are based on an erosion EFC factors in factors correspond to a peak eros round types at a 49°C round-conditioning erosion EFC factors are approximately approximately 0.7, 1.9, 2.2, and 2.8 at a for an equal distribution of these three n above technical manual and help the Arerosion life and erosion EFC factors are type and conditioning temperature-depen of magnitude more limiting than its associations.	teria for each cannon tube type, teria help in cannon inventory ration. This represents a notable amation when using the latest of Cannon Erosion Code to comp d in the 120-mm M256 tank car group of charge/projectile com tor of 1.0 for the M865 round by it is consistent of the manage it is made at 21 and 22 an	and designanagement technology charge/projunte a cartrannon at mulbinations by the at a 21 meters from EFC for rounderature. The M256 ct. They are k, and will	mates a cartridge/zone fatigue nt. However, the manual lac y gap for tank and artillery er jectile combinations. Our re- nidge or round-conditioning te- used in a specific tank or art 1°C round-conditioning temps in the rear face of the tube. For factors are approximately 1.5. conditioning temperature, as he respective erosion EFC fac- amon fatigue life and fatigue e not round type or condition further help the Army manag	e effective ks a designamon sys- port outlife factor for mperature the M86, 4.2, 5.0, and the restors are age effect factors are age to system.	full charge (EFC) factor for each matted cartridge/zone crosion EFC terms, since crosion condemnation mes a detailed computational and the M855, M829, M829A1, and s. Our report further outlines the mon. The following crosion EFC requested by PM-TMAS. These is, M829, M829A1, and M829A2 and 6.3. Similarly, the respective crosion EFC factors are opproximately 1.1, 3.0, 3.5, and 4.4 tors are officially specified in the crature-dependent. M256 cannon in inventory. They are both round
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The preliminary experimental 120-mm M829E3 kinetic energy round data described here represent a stage in the development cycle that occurred about a half year to a year ago. The computational erosion predictions are guided and supported by substantial field and laboratory data, including data from firing tests, laboratory tests, and nondestructive/destructive cannon erosion characterizations. This information is intended to provide a "snapshot" of development for that period, and is not directly related to the future type-classified M829E3 kinetic energy round. During that period, these modeling predictions put the program about 40 rounds shy of its required 180-round minimum program target, so further round optimizations will likely include changes in the weight and configuration of the propellant, projectile, case, and possible ablative. Results of this erosion analysis, erosion effective full charge factor analysis, and comparisons to the round's advanced type-classified counterpart are provided for the preliminary experimental M829E3 kinetic energy round used in the 120-mm M256 cannon at multiple round-conditioning temperatures. The computational method consisted of using our Unified Cannon Erosion Code. Differences exist between the preliminary experimental M829E3 kinetic energy round and its advanced type-classified counterpart including increased propellant weight, increased projectile weight, and RPD380 propellant instead of JA2 propellant. The preliminary experimental M829E3 kinetic energy round erosion analysis achieves erosion condemnation in a lesser number of rounds, and the worst eroded region has moved slightly more than a half meter up-bore compared to its advanced type-classified counterpart.					
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Cellular automata simulations can be used to capture many of the essential features of processes that are difficult to model. They are particularly useful in the study of nonlinear dynamical systems that have complex continuous solutions. In this study, cellular automata models have been employed to investigate the nature of the vapor deposition process by exploring the natural evolution of dynamical dissipative systems using self-organized critical system analysis and spatial scaling measures. A new numerical technique is introduced to analyze the intrinsic structure of evolving surface topography in an effort to better understand the dynamics of the growth processes. This technique is being used to validate the integrity of deposition models through a comparative analysis with experimental data and to determine if a correlation exists between intrinsic surface structure and parameters controlling the deposition process.					
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6. AUTHOR(5) A.A. Kapusta (Materials Analytical S Duanesburg, NY) and J.H. Underwo		*			мануу 660 даланын мана
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Results are presented of a scanning electron microscope fractographic study of a circa AD83 iron nail from the Roman fortress at Inchtuthil, Perthshire, Scotland. The fracture surface studied was created under embrittling conditions of low temperature, an added stress raiser, and high strain-rate loading. Fractographic features are discussed in relationship to the classic cataloguing and metallographic examination of the Inchtuthil nails in earlier work by Angus, Brown, and Cleere.					
14. SUBJECT TERMS Scanning Electron Fractography, Roi	man Nai	1.			15. NUMBER OF PAGES
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6. AUTHOR(5)			
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Never has the need for simulation in design of components been more acute. Today's business environment requires innovative thinking in product development, especially for the 'big-ticket' ordnance items such as main battle tanks and armament. The manufacturing costs of these tems and related components prohibit use of the classical method of product development, which includes initial design, prototype manufacture, system testing, and redesign. The answer lies in the use of virtual performance simulation to assess a system's response before any hardware is manufactured. Up-front costs are greatly reduced since the system components reside in virtual space, allowing for rapid electronic design thanges and optimization by simulation rather than iterative testing of costly hardware.

One must not be overly enamored by the power and function of the simulation tools. They are just mathematical models written by mere mortals, the execution of which closely mimics nature but does not actually reproduce it. Ultimately, these simulations need to be validated before one becomes comfortable in their use. There are various ways to validate a simulation code. First, one may use dedicated and controlled ests void of extraneous noise to establish relational characteristics among a few test variables. The results may then be directly compared to simulations, with validation achieved when output closely matches the test data. The second method involves comparing simulated results to inherently noisy field-generated test data. The best one may expect to achieve from this type of validation is trends in the responses relative o variations in the system parameters. It is the purpose of this report to validate a coupled simulation package for the accuracy assessment of arge caliber weapons. The simulation packages include SIMBAD, a finite element gun dynamics code, and BOOM, a projectile flight dynamics code. These two models have been coupled so that the output of SIMBAD is the input to BOOM. Simulated results are compared to field-generated accuracy firings for the M1A1 tank, thus method two validation was used to assess the worth of this endeavor.

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6. AUTHOR(5) S.L. Lee, D. Windover (Benet and F M. Doxbeck, and TM. Lu (RPI)	PI, Troy, NY),				
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13. ABSTRACT (Maximum 200 words) Two-dimensional image plate applications in x-ray diffraction and x-ray reflectivity characterization, using grazing-incidence geometry and radiation from a conventional x-ray tube, were explored. X-ray diffraction and x-ray reflectivity data were obtained from a conventional diffractometer with Si(Li) detector. These data complement image plate results to give more complete phase and structure information. Protective chromium coatings, electrochemically deposited onto the bore of steel cylinders, were investigated. Retained austenite content in martensitic steel was measured in simulated, inside-diameter, bore geometry. This approach demonstrates the versatility of the method for nondestructive chemical analysis and phase differentiation of interior bore surfaces in piping structures. MATLAB-based processing software was developed to facilitate quantitative image analysis, including multiple 2θ scans, χ-plots, and pole figure reconstruction from multiple φ images, where χ and φ designate, respectively, specimen tilt and rotation. In x-ray reflectivity applications, 12-nm tantalum and 80-nm tantalum oxide thin films sputtered on (100)-oriented silicon wafers were investigated. Density and thin-film thickness were obtained from specular reflectivity modeling involving the periodicity of the interference fringes. Two-dimensional Kiessig interference-fringe images were analyzed and compared to conventional specular x-ray reflectivity images for the measurement of thin-film thickness and thickness uniformity over a sample.					
14. SUBJECT TERMS Digital Film, Image Plate, Chromium, Tantalum, Tantalum Oxide, Austenite,			15. NUMBER OF PAGES		
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6. AUTHOR(5) Dean W. Matson (Pacific Northwest Edwin D, McClanahan (Pacific Nort Sabrina L. Lee, and Donald Window					
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Tantalum offers a number of attractive properties for gun bore coating applications, including a high melting temperature, high ductility, and an environmentally friendly deposition method. However, vapor-deposited tantalum can appear in both the characteristic body-centered-cubic phase found in the bulk material, and in a very brittle and less desirable "beta" phase. Presence of the beta phase in bore coatings is considered undesirable because of its brittleness and resulting failure as the coating is stressed. A high-rate triode sputtering system with a cylindrical coating geometry was used to produce thick tantalum coatings on 4340 steel, smooth bore cylindrical substrates. A systematic series of tests was performed to evaluate the effects of sputtering gas species (argon, krypton, xenon) and substrate temperature (100° to 300°C) during deposition on the phase and microstructure of the coatings. Heavier sputtering gases and higher substrate temperatures were found to promote the formation of body-centered-cubic phase tantalum coatings. Use of a movable target assembly was shown to promote the production of dense, single-phase tantalum coatings.					
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Cannons with bore coatings are necessary to reduce erosion in current and future high-performance combat systems. In 1996, we developed a unique erosion model for cannons with bore coatings. Since that time, our results from this model have been published for a number of important Army and Navy gun systems with bore coatings. The erosion model for cannons with bore coatings is guided and calibrated and correlates very well with considerable gun system firing data and subsequent laboratory analysis of fired specimens. Our confidence in the model has grown yearly such that we have decided to publish the details of this model. Coated cannon bore crosion does not simply proceed in an outward to inward progressive ablative fashiom, since coatings typically spall instead of progressively ablate. This is the only known erosion model for cannons with bore coatings to account for all aspects of the typical firing-induced cannon erosion mechanism. The typical mechanism includes: Heat-check cracking of the bore coating Bore coating shrinkage leading to progressive widening of these cracks Combustion gas-induced interface degradation of the exposed substrate metal Abrupt interfacial spalling of the bore coating platelets due to linked interfacial degradation that forms pits Subsequent substrate metal gas wash-to-erosion condemnation A very fine bore coating crack provides a narrow combustion gas path to the metal substrate thus producing limited interfacial substrate degradation. In contrast, a progressively widened/extended bore coating crack due to fining-induced bore coating shrinkage provides a wide combustion gas path to the metal substrate producing substratial interfacial substrate degradation. The purpose of this report is to review typical cannon erosion mechanisms, highlight the resultant cannon coating erosion model, show how this very critical coatings model incorporates into our overall cannon erosion code, and provide an example. The example is an updated erosion prediction for the experimental nonablat					
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The firing of any gun, electromagnetic or otherwise, imparts substantial momentum to the launcher, and ultimately the weapon platform. The objectives of the future combat system program call for similar lethality to a current heavy tank on an extremely lightweight vehicle of nominally twenty tons. Prior experience with the M55! Sheridan, a light tank first put into production by the United States in 1966, raises concern that firing large caliber armaments from light vehicles may result in unacceptable crew discomfort and vehicular reaction during recoil. This report provides a future combat system armament integration perspective for railgun recoil.					
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